"SUM" is Better than Nothing: Toward a Sociology of Urban Mathematics Education

William F. Tate
Washington University in St. Louis

Celia Rousseau Anderson
University of Memphis

Daryl A. Tate
University of Arkansas at Little Rock

The purpose of this commentary is to serve as a warning that developing and testing theories is central to making urban mathematics scholarship a visible research enterprise. More specifically, I will argue that there are lessons to be learned from the social sciences literature that can inform the advancement of a robust, theoretically based, empirical project in urban mathematics education research. In addition, these fields of social science are part of the rationale for why putting the "urban" in mathematics education scholarship is important. (Tate, 2008a, p. 5)

Nearly ten years after this call to develop an urban mathematics education research enterprise, Anderson and Tate (2016) described the conceptual components of a sociology of mathematics education. They argued several questions should inform the development of a sociology of mathematics education. Adapted and expanded from their analysis, we submit the following questions to serve as starting points for scholars interested in sociological approaches to the study of mathematics education in urban communities:

1. Is geography a factor in opportunity to learn in urban mathematics education?
2. How does mathematics education socialize in urban communities?
3. Does credentialing influence opportunity in urban mathematics education?

WILLIAM F. TATE is the Edward Mallinckrodt Distinguished University Professor in Arts & Sciences and Dean & Vice Provost for Graduate Education at Washington University in St. Louis, One Brookings Drive Campus Box 1183, St. Louis, MO 63130-4899; e-mail: wtate@wustl.edu. His interdisciplinary scholarship concentrates on two main areas: mathematics, science, and technology education, specifically, in metropolitan America; and geospatial and epidemiological approaches to the study of the social determinants of education and health outcomes.

CELIA ROUSSEAU ANDERSON is a professor in the Department of Instruction and Curriculum Leadership in the College of Education at the University of Memphis, 3798 Walker Avenue, Memphis, TN 38152; email: croussea@memphis.edu. Her research interests include equity in mathematics education, urban education, and critical race theory.

DARYL A. TATE is an assistant professor and the coordinator of Learning Systems Technology Education at the University of Arkansas at Little Rock, 2801 S. University Avenue, Little Rock, AR 72204; email: datate@ualr.edu. His research and professional interest coalesce into four interrelated areas: (a) on-line learning communities, (b) multimedia integration into curriculum and technology pathways, (c) technology professional training and development, and (c) digital methodology to enhance scholarly inquiry.

4.   What societal factors influence urban mathematics education?

In the following sections, we explore each of these questions relative to mathematics education in urban communities. We describe in brief what a program of study focused on a sociology of urban mathematics (SUM) education entails. We view this as a starting point, rather than an all-inclusive framework.

Geography of Opportunity

A regime is a public-private partnership designed to produce a specific goal. By way of law, public policy, and social custom across urban communities in America, segregation regimes framed the nature of opportunity in local economies (Rothstein, 2017; Tate & Jones, 2017). Federal lawmakers and policy elites; local municipality leaders; and private sector actors, such as real estate brokers, churches, financial institutions, and neighborhood associations, collaborated to restrict African American families' access to quality neighborhoods. The segregation regime limited the access of African American families to communities perceived as more desirable for White families and steered many of them to segregated public housing and high poverty neighborhoods. African Americans' opportunities to acquire residential housing, wealth, and to accrue value from community-based related services, such as education and health care in a region, diminished in appreciable fashion. Consequently, neighborhood poverty in urban communities concentrated, and for low income African Americans and Latinos/as endures for multiple generations (Sharkey, 2013). Given that education has served as the primary mechanism supporting income mobility in the United States (Duncan & Murnane, 2015), understanding the geography of opportunity in education represents a primary consideration for scholars in mathematics education (Tate, 2008a, 2008b).

Geographic factors within neighborhoods and communities influence the relational, organizational, and collective actions impacting the social formation of opportunity and access in mathematics education (Anderson & Tate, 2016; Tate, 2008a). Hogrebe and Tate (2015) described the implications of these social formations for conducting research in mathematics education where the school district serves as the unit of analysis:

> In the case of neighboring school districts, there is clustering created by spatial proximity that produces unique local contexts and concomitant within-group correlation. In many instances, families and students within school districts tend to be somewhat similar on factors such as education, income, and housing. The built environment does not start and stop abruptly at district boundary lines. The argument is that similarity across local contexts functions as a spatial continuum in geographic space. Therefore, while unique local contexts certainly exist and the correlation of factors within them must be accounted for, analysis techniques that do not consider the spatial continuum may be inappropriate for spatially clustered data such as school districts within a region or state. (p. 100)
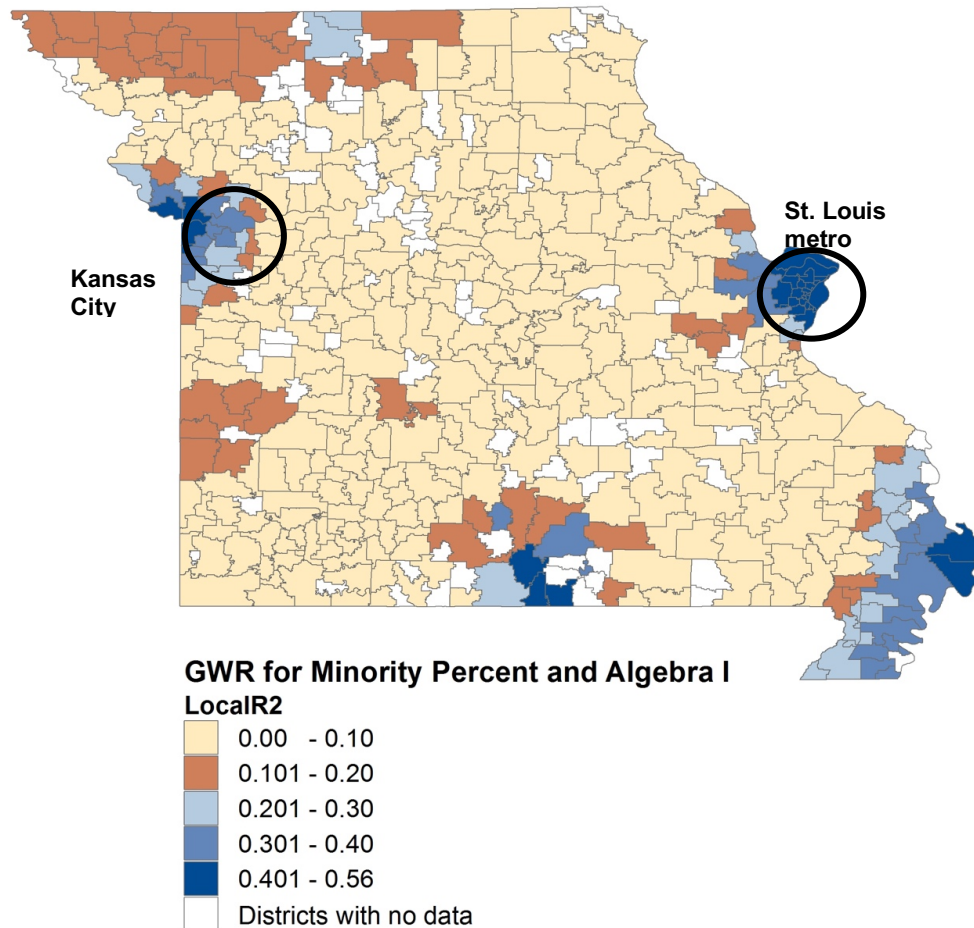
GWR for Minority Percent and Algebra I
LocalR2

	0.00 - 0.10
	0.101 - 0.20
	0.201 - 0.30
	0.301 - 0.40
	0.401 - 0.56
	Districts with no data

Figure 1. Local R^2 values for the relationship between minority percent and Algebra I scores in Missouri school districts.

To account for regional clustering of school districts, several STEM (science, technology, engineering, and mathematics) education studies use geographically weighted regression (GWR), a method designed to incorporate the underlying spatial continuum (Hogrebe & Tate, 2012; Tate & Hogrebe, 2015). The modeling technique allows relationships to vary across groups (e.g., school districts in a state), as does multilevel modeling (MLM), but unlike MLM, it does not ignore the similarity among neighboring school districts. The methodology estimates where variable relationships differ across regions and throughout the state. Thus, the approach provides important insight into the geography of opportunity in mathematics education. For example, Hogrebe and Tate (2012) examined the relationship between district composition variables and End of Course Algebra I scores across the state of

Missouri. Figure 1 illustrates R^2 values across the state. Several distinct cluster patterns emerged with local R^2 values ranging from close to zero to .56. School districts in metropolitan St. Louis and Kansas City formed two distinct clusters of high R^2 values.
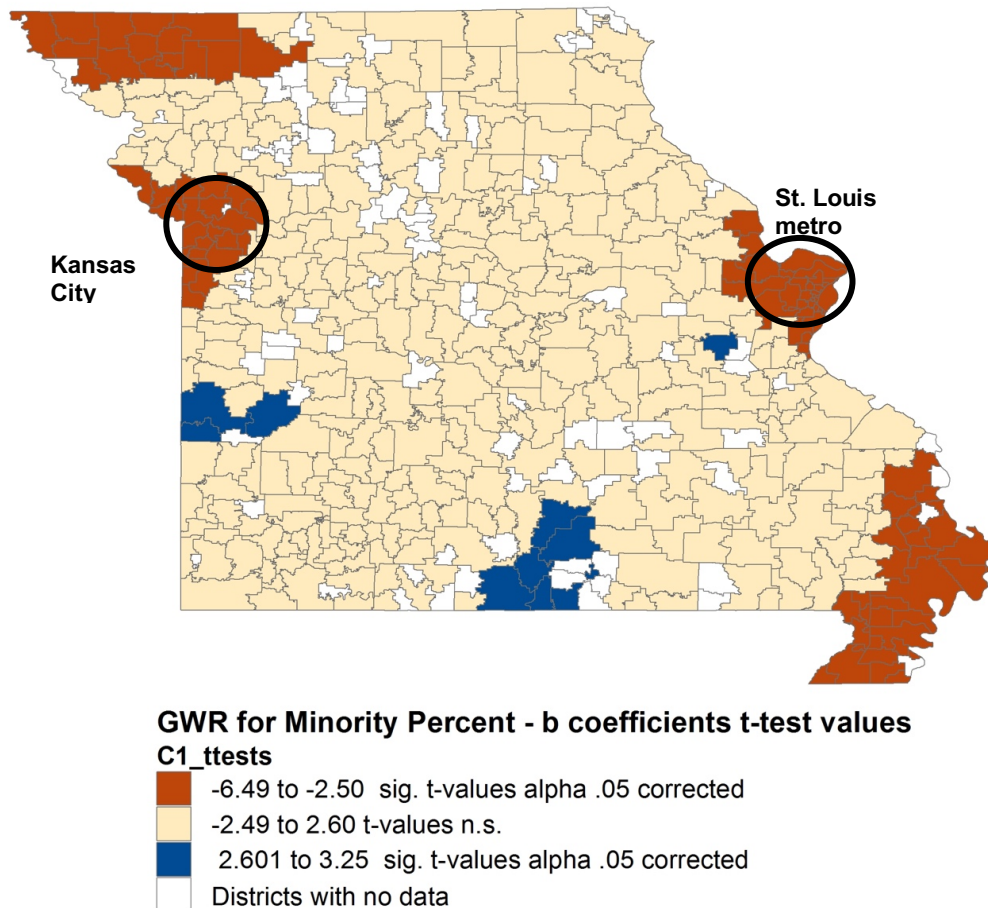

Figure 2. Statistically significant beta coefficients for the relationship between minority percent and Algebra I scores in Missouri school districts. Negative coefficients indicate higher minority percentage associated with lower Algebra I scores. Multiple t-tests for beta coefficients corrected for false positive rate by Benjamini-Hochberg (B-H) procedure (Thissen, Steinberg, & Kuang, 2002).

Figure 2 shows that the statistically significant beta coefficients cover the same two large urban metro regions. The negative sign of the coefficients suggests

that lower Algebra I scores were associated with higher percent minority in the school district. In contrast, the southwest border cluster had positive beta coefficient signs that associate higher minority percent with higher Algebra I scores. Estimates of the relationship between minority percent in the school district and Algebra I performance across a majority of the state did not elevate to statistical significance.

The Missouri case offers an important lesson for theory building in the sociology of urban mathematics education. The negative relationship between percent minority enrollment in a school district and mathematics attainment found in urban communities warrants attention in theory development. Using Missouri as a case, Hogrebe and Tate's (2012) findings affirm the rationale of the National Science Foundation (NSF) to develop a specific STEM intervention designed for urban school districts. Williams (2018) reflected on the call to develop the NSF's Urban Systemic Initiative (USI) program:

> Urban school systems enrolled approximately 50% of U.S. public school K–12 students. Moreover, as noted in the USI solicitation, there is a well-documented disparity between the academic performance of these students and that of their counterparts in suburban schools, an achievement gap that is not independent of uneven allocation of resources, including experienced (and highly competent) teachers, as well as the paucity of advanced courses, curriculum materials, instructional equipment and facility. (pp. 12–13)

Too often in theory building and in the establishment of traditions in education research, the challenges and assets of urban communities fail to emerge as foundational in the research, evaluation, and related reform. Charged with oversight for education, states need to account for how the distribution of opportunity to learn factors related to mathematics education vary within their borders. Many state agencies lack the infrastructure to realize this goal. Read and Atinc (2017) call for infomediaries, civil society organizations (e.g., universities), researchers, and the media to translate data into actionable information designed to foster shared learning among parents, teachers, administrators, and policymakers. Urbanists focused on researching the geography of opportunity in mathematics education should engage fully this call. Geography matters.

Socialization

In their 2016 chapter in the *Handbook of International Research of Mathematics Education* (3rd ed.), Anderson and Tate examined the existing research addressing the question: *How does mathematics education socialize?* Their review focused on research involving mathematics socialization and mathematics identity. These processes of mathematics socialization and identification have emerged as the foci of significant lines of scholarship in mathematics education, particularly with regard to the experiences of students of color in mathematics (Langer-Osuna & Es-

monde, 2017; Martin, Anderson, & Shah, 2017). While a growing body of research related to identity and socialization in mathematics exists, we submit that the role of *urban* mathematics education in the socialization process has not been addressed substantively to date. We acknowledge that many of the studies of socialization and identity involve students who attend urban schools (Martin & Larnell, 2014). Moreover, these studies have provided insight into the process of racial-mathematical socialization (Martin, 2006; Martin et al., 2017). However, we submit that research in mathematics education has yet to explore the ways in which *urban* mathematics education socializes.

We refer to a study by Jackson (2009) to illustrate how this attention to urban mathematics education might expand our understanding of the socialization process. Jackson's research documents the instructional practices of a 5th grade mathematics teacher in an urban school, which she calls Johnson Middle School, and the role of these teaching practices in the mathematics socialization of two African American students. Jackson also interrogates the ways that larger school and community-wide discourses about students shape what happens in the classroom. According to Jackson, the teacher's classroom "as all classrooms, was a nexus of discourses about youth, about mathematics, and about pedagogy. The local practices were influenced by discourses about poor children of color and mathematics that circulated outside of Johnson Middle School" (p. 195). The study provides important insight into the interactions of the local context in shaping teachers' conceptions of students and mathematics and the impact of these conceptions on students' experiences.

Yet, using Jackson's (2009) study as a starting point, we offer additional questions that might illustrate the potential of a sociology of *urban* mathematics education in the examination of mathematics socialization. Specifically, what features of urban schools and systems influence the mathematics socialization of students in these schools? In thinking about this question in relation to Jackson's (2009) study, we consider it crucial to note that Jackson conducted her research in an urban charter school that was part of a larger charter network. According to Jackson, although all the students in the school were of color, the staff was predominantly White and most had been teaching at the school for less than two years. She also reveals that the school's basic-skills mathematics curriculum had been created by the charter school network. The school operated under the assumption that a deficiency existed in the entering 5th grade students' values, academic backgrounds, and behaviors. As a result, the school implemented strategies to intervene in these areas, including a 3-week summer intensive initiation for new students to learn the school norms, attention to "character building," and a monetary system of rewards and sanctions for behavior.

A sociology of urban mathematics education might focus on the typicality of schools such as Johnson Middle School and seek to interrogate the ways in which the features of these schools influence mathematics socialization. For example, the

fact that Johnson Middle School was a charter school is potentially noteworthy from a sociology of urban mathematics education perspective for several reasons. One of the hallmarks of urban education reform has been the growth of charter schools and charter school management organizations. This growth has occurred within a larger market-based approach to educational reform or as part of urban districts' adoption of a portfolio management model (Anderson & Dixson, 2016; Bulkley, Henig, & Levin, 2010; Dixson, Royal, & Henry, 2014). These schools have increased levels of autonomy, relative to traditional district schools, with respect to issues such as curriculum and instruction, staffing, budgeting, and so on (Berends, 2014; Bulkley, 2010). We do not know from Jackson's (2009) study how the specific history or characteristics of Johnson Middle School might reflect the larger trends of urban education reform. However, given the role of charter schools in urban districts, we consider it worthwhile to examine the ways in which settings such as Johnson might shape the mathematics socialization process.

For example, we might consider the socialization process at Johnson Middle School (Jackson, 2009) within the larger context of charter school organizations. Specifically, some charter school organizations reflect what social scientists refer to as a "no-excuses" approach. According to Carr (2013), no-excuses reformers believe that—

> low-income children must be taught, explicitly and step-by-step how to be good students. Staff at a growing number of "no-excuses" charter schools—which are highly structured and emphasize college matriculation—are prescriptive about where new students look (they must "track" the speaker with their eyes), how they sit (up-right, with both feet planted on the ground, hands folded in front of them), how they walk (silently and in a straight line, which is sometimes marked out for them by tape on the floor), how they express agreement (usually through snaps or "silent clapping" because it's less disruptive to the flow of the class), and, most important, what they aspire to (college, college, college). This conditioning (or "calibration," or "acculturation," as it is sometimes referred to inside no-excuses schools) starts with the youngest of students. (pp. 42–43)

While we do not know from Jackson's (2009) description whether Johnson Middle School reflected this no-excuses model, features such as a 3-week initiation for new students, attention to "character building," and a college prep mission suggest at least some alignment with the no-excuses approach. On the surface, this attention to the "cultural" model utilized by a segment of the charter school sector may seem far afield from mathematics education research. Yet, as Jackson's research demonstrates, these organizational perspectives on students can have a significant influence on the ways that schools socialize students into mathematics. Thus, we submit that a sociology of urban mathematics education might situate the socialization process within this larger charter context.

The role of the accountability system in the socialization of students in urban schools represents another element of schooling that should be considered in a sociology of urban mathematics education. Urban schools often experience conflicts between the accountability system and the time and curriculum needed to support teaching for understanding (Gamoran et al., 2003; Walker, 2012). Depending on the structure of the accountability system in the local context, schools can feel substantial pressure to focus on preparing students for state tests in order to avoid sanctions that can include take-over or closure (Anderson, Bullock, Cross, & Powell, 2017). Based on Jackson's (2009) description, we do not know what role the accountability system might have played in the approach to mathematics evidenced at Johnson Middle School. However, the focus on "basic skills" and procedural knowledge represents a common response to high-stakes accountability (Gamoran et al., 2003; Walker, 2012). Understanding the nature of the accountability system in the local context and the pressures around student testing represent potentially important considerations within a sociology of urban mathematics education.

Finally, situating cases such as Johnson Middle School (Jackson, 2009) within the larger trends of urban education reform also requires consideration of the role of issues such as teacher shortages, teacher turnover, and teacher capacity in the mathematics socialization process. For example, according to Jackson, only a few of the teachers had worked at Johnson since its opening 2 years before the start of her study. Again, we do not know what the rate of turnover had been at Johnson. However, it is well-documented that urban schools are characterized by higher rates of teacher turnover than schools in other settings and that this turnover is a key factor driving shortages of qualified and effective teachers (Ingersoll & Merrill, 2013). Moreover, research on the impact of turnover has pointed to the negative impact not only on the achievement of students whose teachers leave but also on other students within the school. This finding suggests that the harmful effect of teacher turnover is at least partially related to issues of school-wide culture (Ronfeldt, Loeb, & Wyckoff, 2013). Given the prevalence of turnover in many urban schools, we submit that a sociology of urban mathematics education would attend to these issues in an examination of the socialization process.

In this section, we sought to outline potential areas of focus for research on mathematics socialization grounded in a sociology of *urban* mathematics education. This is not to suggest that research on mathematics socialization involving urban schools and students does not exist (Martin & Larnell, 2014; Walker, 2012). Rather, we sought to highlight ways in which scholarship on mathematics socialization might engage what we know from sociological research around urban education. We utilized Jackson's (2009) study as a reference point because her research clearly links mathematics socialization processes to larger discourses within the school and community. Our purpose was not to suggest that her research was lacking in any way but simply to illustrate how this work could be bridged with other bodies of

scholarship to craft an account of mathematics socialization informed by a sociology of urban mathematics education.

Credentialing and Societal Factors

In addition to its socializing role, mathematics education involves the credentialing of students and their teachers (Anderson & Tate, 2016). The credentialing problem space requires both a geospatial perspective and racial lens. Toldson (2014) reported that (a) Black children received access to less cognitively demanding coursework with greater misalignment to college admission requirements, (b) schools assign Black children the lowest paid and least experienced teachers at higher rates, and (c) Black students are the most likely to have teachers credentialed through alternative teacher certification programs.

Education as a credentialing mechanism dates back in history several centuries. Adam Smith (1776) implicitly framed the role of education as credential, stating, "The public can encourage the acquisition of those most essential parts of education by giving small premiums, and little badges of distinction, to the children of the common people who excel in them" (p. 352). Operating as modern day "badges of distinction," college-preparatory tracks in high school serve a credentialing function for students. This track offers academic preparation in mathematics aligned with access to post-secondary education and variety of competitive vocational opportunities.

Debates related to the design, organization, and content of the college preparatory math track remain central to opportunity to learn in urban communities. Over the past 3 decades, calculus served as the mathematics credential required for students seeking entry into the nation's top colleges and universities. Thus, the pathway to calculus completion in high school drove access and opportunity discourse. Math track trajectories gained perceived value in the credentialing process in relationship to the calculus entry point. School districts reverse-engineered their mathematic programs putting great emphasis on building the prerequisite knowledge associated with readiness for calculus. Thus, early entry into Algebra I and Algebra II emerged as guides for determining student excellence. This perception persisted despite signals that calculus completion in high school did not consistently result in students placing out of calculus in college. In fact, many high school calculus completers start their college mathematics education in calculus readiness coursework. Noting these college placement trends and the racial and socioeconomic disparities in calculus enrollment in high schools, reformers call for an alternative post-secondary pathway with statistics as the content driving the new learning opportunity (Burdman et al., 2018). The urban sociology of mathematics education project corresponds with documenting the alignment of any new credentialing pathway and determining access to the post-secondary education system.

Statistics as the primary secondary school credential also stems from changes in the scientific enterprise and social sciences including the increased importance of data science, bioinformatics, and modeling. Moreover, statistical modeling and computational science continue to grow in their importance as a tool to survey and to police the urban underserved:

> The advocates of automated and algorithmic approaches to public services often describe the new generation of digital tools as disruptive. They tell us the big data shakes up hidebound bureaucracies, stimulates innovative solutions, and increases transparency. But when we focus on programs specifically targeted at poor and work-class people, the new regime of data analytics is more evolution than revolution. It is simply an expansion and continuation of moralistic and punitive poverty management strategies that have been with us since the 1820s. Data scientists push high-tech tools that promise to help more people, more humanely, while promoting efficiency, identifying fraud, and containing costs. The digital poorhouse is framed as a way to rationalize and streamline benefits, but the real goal is what it has always been: to profile, police, and punish the poor. (Eubanks, 2018, pp. 37–38).

Social equity calls for urban mathematics education researchers to evaluate how students come to understand the use of mathematics in society. The design of credentialing pathways should link not only to post-secondary education opportunities but also to how society uses mathematics in context. In a speech given on March 31, 1968 at the National Cathedral in Washington, DC, Martin Luther King, Jr. warned us about this era:

> There can be no gainsaying of the fact that a great revolution is taking place in the world today. In a sense it is a triple revolution: that is, a technological revolution, with the impact of automation and cybernation; then there is a revolution in weaponry, with the emergence of atomic and nuclear weapons of warfare; then there is a human rights revolution, with the freedom explosion that is taking place all over the world. Yes, we do live in a period where changes are taking place. (para. 7)

Ever the prophet, today Dr. King's words ring true, with automation being used as a weapon against the poor living in urban America. Preparing informed citizens requires a secondary mathematics credentialing pathway that supports students' opportunities to understand how automation influences their experiences, support structures, and life course. Tate (1994) argued that economics drives the reasons situations are mathematized. The first goal is to maximize the return on information with respect to organizational aims. The second goal is to minimize the challenges and responses to how the mathematizing informs the decision-making process. In the age of automation and big data, mathematics represents both an opportunity accelerant toward the economic advantages associated with attaining a post-secondary education and the foundation of a technological world assigning merit to citizens' requests for health and other developmental supports. Understand-

ing this duality and tension represents a central problem space in a sociology of urban mathematics education.

The importance of credentialing and digital advances in society extends to teachers. The preparation, credentialing, and distribution of teachers have been demonstrated to influence urban students' opportunities to learn and to achieve in mathematics. According to Carver-Thomas (2018), approximately 40% of new Los Angeles Unified School District teachers fall short of completing the preparation and requirements for a preliminary teaching credential. In the Stockton Unified, over 50% of the new teachers lack the credential and associated preparation. Severe shortages exist in mathematics and bilingual education across the state of California. Shortages exist nation-wide. In the state of Texas, more than half of the students reside in school districts where teacher certification requirements have been waived (Dugyala, 2018). The potential consequences of these credentialing challenges on the teaching and learning conditions in urban schools represent another area of study in the sociology of urban mathematics education.

Some scholars suggest digital advances associated with online learning offer a remedy to credentialing inequalities. Christensen, Hor, and Johnson (2010) projected that 50% of all high school classes will be offered online by 2020. An ambitious projection if framed as an actual count of classrooms, nevertheless the ability to offer online content across the secondary mathematics curriculum exists. The primary advantage of online learning involves how the delivery method levels the playing field for students experiencing geographic disparities with respect to educational resources and quality learning experiences (Kuo, 2014). Online learning provides anytime, anywhere learning experiences, while allowing access to interactive format offering varied demonstrations and practice sites, emerging communication innovations, and responsive assessment practices. In addition, advocates of online platforms promise that digital learning increases the numbers of students that can be reached as districts struggle to find and to pay for credentialed teachers. Evidence suggests that a blended option consisting of face-to-face and online opportunities produces learning outcomes similar to traditional classrooms, yet better than online only (Escueta, Quan, Nickow, & Oreopoulos, 2017). The role of digital learning as an equity project to address teacher distribution disparities aligns with the sociological study of urban mathematics education.

As digital learning formats developed and matured, online teacher education programs emerged to address the teacher shortage disparities. For example, a large state university in a major metropolitan region of Texas offered an online post baccalaureate program designed to improve teacher candidate diversity and to increase the candidates in areas of shortage such as mathematics (Harrell & Harris, 2006). The 18-credit hour program consisted of 12 credit hours of fully online study and 6 credit hours of practicum. Early results indicated the program attracted more career changers and minority candidates, while increasing the institution's candidates in

teacher shortage fields of mathematics and science. Online teacher education represents a potential growth industry as geographic disparities in teacher distribution fail to dissipate. The need to evaluate the quality and efficacy of online teacher education represents another area to prioritize in the sociological study of urban mathematics education.

SUM

Why invest into the development of a sociology of urban mathematics research? If we sum up the country's population, over 60% of the U.S. population lives in an urban city, yet urban cities make up less than 4% of the landmass in the country (Cohen, 2015). While our essay focused on the United States, mathematics education research is a global enterprise. UNICEF (2012) estimated that over one billion children live in cities and towns worldwide. Additionally, they reported that by 2050, 7 in 10 people will live in cities across the globe. The massive volume of children calls for understanding the scale and nature of poverty and how it influences opportunity to learn mathematics in urban areas.

In addition, the need to identify barriers and to remove obstacles constraining opportunities for urban students in mathematics will grow as the population in cities and metropolitan regions increases. A clear understanding of the state of the infrastructure and of the delivery services to support mathematics learning in urban cities is connected tightly to reducing inequality and poverty reduction. Credentialing functions operate at different levels of government, corporate sector, and nonprofits. Evaluating how these institutions partner in urban communities to form opportunity regimes in mathematics education or flounder is a priority. SUM effort on this front is better than nothing.

Acknowledgments

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